Notes

I. Introduction

II. Radiological Control Program

A. Overall program

The Radiological Control Program consists of the commitments, policies, and procedures that are administered by a site or facility to meet the EH Health and Safety Policy.

The Radiation Protection Program required by 10 CFR Part 835 is an element of the overall Radiological Control Program.

The Radiological Control Program should address the following:

- Requirements
- Responsibilities
- Programs/procedures
- Assessments

B. Size of the program

Radiological Control Programs vary in size.

There are several factors that may affect the magnitude of a Radiological Control Program. The specific mission, types and quantities of radioactive material, and the radiation-generating devices that will be used at the site are just a few.

Notes

III. Elements of a radiological control program

A. Requirements

Notes

B. Responsibilities

C. Programs/procedures

Notes

D. Assessments

Notes

IV. List of Radiological Control Program Elements

- Organization and administration
- Personnel training and qualification
- Quality assurance
- ALARA
- Radiological Work Control
  - Procedures
  - Radiological Work Permits
- Posting and labeling
- Radioactive material control
  - Source control
  - Release of materials
  - Receipt and transportation
- Radiation-generating devices
  - Sealed source
  - X-ray machines
- Entry control
- Contamination control
- Instrumentation/alarms
- Monitoring
  - Workplace
  - Effluent
  - Environmental

Notes

- Dosimetry
  - External
  - Internal
    - Program management (e.g., staffing, technical basis, procedures, quality assurance)
    - Individual monitoring (e.g., air monitoring, contamination monitoring, bioassay)
    - Internal dose evaluation

- Respiratory protection

- Facility specific features
  - Uranium
  - Plutonium
  - Tritium
  - Accelerators

- Radioactive waste management

- Emergency response

- Records

- Assessments/performance indicators

Notes

I. Introduction

II. Purpose of DOE Order 5480.22

The intended purpose of DOE Order 5480.22, *Technical Safety Requirements*, is "to clearly state the requirements to have Technical Safety Requirements (TSRs) prepared for DOE nuclear facilities and to delineate the criteria, content, scope, format, approval process, and reporting requirements of these documents and revisions thereof."

On October 10, 2000 an Interim final rule was published in the Federal Register for 10 CFR 830, "Nuclear Safety Management". The Interim Final Rule was effective December 11, 2000, and codifies requirements for TSRs in 10 CFR 830.205. The new rule requires contractors to develop and submit TSRs to DOE for approval by April 10, 2003. In the interim, contractors are required to meet existing safety bases, including TSRs.

TSRs are a critical element in the overall DOE safety program.

A. Definitions (Paragraph 6)

- Technical Safety Requirements are those requirements that define the conditions, safe boundaries, and the management or administrative controls necessary to ensure the safe operation of nuclear facilities and to reduce the potential risk to the public and facility workers from uncontrolled releases of radioactive materials or from radiation exposure due to inadvertent criticality. Technical Safety Requirements consist of safety limits, operating limits, surveillance requirements, administrative controls, use and application instructions, and the bases thereof.

Notes

- A controlled document is content maintained uniformly among the copies by an Administrative Control System (paragraph 6, Item e).

Basis: Summary statements of the reasons for the operating limits and associated surveillance requirements. It shows how the numerical value, condition, or the surveillance fulfills the purpose from the safety documentation.

B. Policy (Paragraph 7)

It is the policy of the Department that nuclear facilities operate Cognizant Secretarial Officer (CSO)-approved Technical Safety Requirements, which prescribe the bounds for safe operation of these facilities in order to protect the health and safety of the public and reduce risk to workers.

The TSRs constitute a contract between the operating contractor and DOE management of the methods that will be utilized or constraints to be applied to minimize the potential risk of operating the proposed facility or conducting the proposed activity.

NOTE: TSRs apply to actions by specific facility personnel and their commitments to responsible DOE managers.

The Technical Safety Requirements document is to be a controlled document.

TSRs are <u>not</u> based upon maintaining worker doses below some acceptable level following an uncontrolled release of hazardous material or inadvertent criticality; rather, the risk to workers is reduced through controls that reduce the <u>likelihood</u> and <u>potential</u> <u>impact</u> of such events.

Notes

C. Source for bases (justification) of TSRs

In the development of limits, set-points, staffing requirements, and other parameters for input into the individual TSRs, the facility/operation-specific Safety Analysis Report (SAR), particularly the accident analyses contained therein, is normally the primary basis.

The limitations that are included in the TSRs should be derived from the facility-specific safety analysis, which considers all credible accidents. This includes the most significant possible releases of radioactive and hazardous materials, criticality scenarios, and the accidental releases expected during the life of the facility.

Careful and thorough examination of these accident analyses will provide values for defining the operational limits necessary to ensure that facility operations do not occur outside the bounds assumed in the analyses. Such an examination will also identify parameters and operating conditions that should be limited in order to reduce, provide warning of, and mitigate the uncontrolled releases of hazardous materials and to prevent inadvertent criticality.

Examples of requirements expected to be developed include:

- Operating limits for principal process parameters
- Technical and administrative conditions that must be met
- Availability of safety equipment and systems
- Critical functions of instrumentation and controls

Notes

Operations within the boundaries of the resulting requirements will provide reasonable assurance that the nuclear facility will not:

- Threaten the health and safety of the public
- Pose an undue risk to workers from the uncontrolled releases of radioactive or other hazardous materials and inadvertent criticality

For facilities that do not have an approved SAR, the technical input into the TSRs must be derived from existing documents/analyses that specifically demonstrate the limiting conditions that the facility is expected to experience during normal operations and potential accident conditions.

In order to serve as the basis for the TSRs, these studies must systematically evaluate:

- All potential off-normal conditions that could occur during the life of the facility
- What could be considered design basis accidents

D. Responsibilities for TSRs

- Prepare → Contractor
- Review → DOE Field Office
- Approve → CSO

Notes

E. Identification of violations

Violations of a TSR occur as the result of four circumstances:

- Exceeding a Safety Limit (SL)

- Failing to take the necessary actions within the required time limit following:
  - Exceeding a Limit Control Setting (LCS)
  - Failing to meet Limiting Conditions for Operations (LCO)
  - Failing to successfully meet a Surveillance Requirement (SR)

- Failing to perform a surveillance within the required time limit

- Failing to comply with an Administrative Control (AC) requirement

As stated previously, compliance with TSRs is required by 10 CFR 830.205, violations may be enforceable under PAAA.

F. Reporting Requirements (DOE Order 232.1A) *Occurrence Reporting and Processing of Operations Information,* July, 1997

- Categorization
  - Emergencies
  - Unusual Occurrences
  - Off-Normal Occurrences

- Notification

- Follow-up notification

- Occurrence Report preparation

TSR ACs may impose additional facility- or operations-specific reporting requirements, which must also be carefully and fully followed.

Notes

Violations of TSRs may need to be reported as part of the Noncompliance Tracking System (NTS). For guidance on NTS reports, refer to Operation Procedure *Identifying, Reporting, and Tracking Nuclear Safety Noncompliances*, June 1998, prepared by the DOE Office of Enforcement and Investigation (EH-10).

G. Ancillary guidance

The TSR document shall be kept current at all times so that it reflects the facility as it exists and is analyzed in the SAR. The TSR must be approved prior to changes in the facility or facility practices.

TSRs should be written in a clear and concise manner, in language that is understandable by those in the facility operating organization. The TSR should not contain excessive details that belong more appropriately in the SAR.

The scope and content of TSRs are to be limited to only the most critical nuclear safety areas. This serves to make TSR Documents more useful for controlling facility safety.

H. Radiological Assessment of TSR Compliance

TSRs typically specify requirements for several areas that may be reviewed as part of a radiological assessment. These areas include:

Area monitors:
- Criticality monitors
- Area Radiation Monitors
- Air Monitors (i.e., real time air monitors, fixed head air samplers)

Notes

Surveillance requirements for area monitors

HEPA ventilation systems and their surveillances

Shift Staffing

- Facility staff qualification, training and retraining

Audits and reviews

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Notes

I. Introduction

The guidance in DOE-STD-1136-2000, *Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities,* should be reviewed in detail prior to conducting an assessment of uranium facilities. The following is a brief overview of the radiological aspects of uranium.

II. Radiological aspects of uranium

A. Radiological properties of uranium

Fifteen radioisotopes exist, but the three of most concern to the uranium industry are:

Uranium-238:
99.7% abundant in natural uranium;
half-life = 4.5 billion yrs,
specific activity = 3.3 E-7 Ci/g

Uranium-235:
0.72% abundant;
half-life = 710 million yrs,
specific activity = 2.1 E-6 Ci/g

Uranium-234:
0.006% abundant;
half-life = 247 thousand yrs,
specific activity = 6.2 E-3 Ci/g

Enriched uranium has a higher content of Uranium-235 than found in nature. Typical enrichment values are:

- 2%-3% Uranium-235: power reactor grade fuel
- >90% Uranium-235: weapons grade material

Notes

Specialized reactor fuel may have enrichments other than those listed above.

The uranium byproduct of enrichment is reduced in Uranium-235 content and is called depleted uranium. Its typical composition is as follows:

- 99.75% Uranium-238
- 0.20% Uranium-235
- 0.0007% Uranium-234

As a result of the differences in specific activities, Uranium-234 may account for a significant fraction, or even the majority, of the radioactivity for enriched uranium.

For example, for 3% enriched uranium (i.e., 3% Uranium-235), the Uranium-234 (with an abundance of 0.03%) would have approximately 6 times the activity as Uranium-238 and approximately 30 times the activity as Uranium-235.

Uranium-238 and Uranium-234 are part of the uranium decay series, while Uranium-235 is part of the actinium series. Therefore, following chemical separation, decay products will continue to grow in. The most significant of these are Thorium-234 and Protactinium-234m from the uranium series and Thorium-231 from the actinium series.

Other small amounts of radioactive material may be present as the result of reprocessing uranium. These include Neptunium, Plutonium, Technetium-99, and other radioisotopes of uranium, including Uranium-232 and Uranium-236.

Notes

B. Radioisotopes

The primary radioisotopes of uranium are all long-lived alpha-emitters. The specific activity (Ci/g) of uranium increases as enrichment increases; therefore, enriched uranium is a more serious radiation hazard.

In most uranium facilities, the inhalation hazard from alpha particles released in the respiratory tract is the predominant radiological hazard associated with the alpha emitting uranium isotopes. In addition, uranium decay products are primarily beta-emitters. For external exposure, the major concern is the high energy beta particle from Protactinium-234m (2.29 MeV). As a result of beta radiation, the typical contact dose with a block of uranium is approximately 200 mrad/hr.

Trace contaminants such as Technetium-99 and Uranium-232 may result in additional external radiation dose when present.

As a result of the alpha-neutron reaction, casks of enriched uranium hexafluoride may also emit neutrons. Typical dose rates are on the order of a few mrem/hr.

Notes

C. Criticality

Uranium-235 and Uranium-233 are both fissile materials; therefore, facilities handling enriched uranium and/or Uranium-233 have the potential for criticality accidents, generating large amounts of neutron and gamma radiation.

D. Toxicological properties of uranium

Uranium is a heavy metal poison and is toxic in much the same way lead or mercury is. For soluble compounds of low enrichments (< 5% Uranium-235), the toxic properties of uranium override the radiological hazards. The kidney is the primary organ of concern.

For insoluble compounds of any enrichment or all compounds of highly enriched uranium, the radiological hazards are limiting.

III. Detection, measurement, and survey techniques

A. Monitoring program

A radiation protection monitoring program in a uranium facility must ensure the detection of typical ionizing radiations over wide energy ranges.

To detect alpha radiation from the uranium isotopes, exposure rate surveys using photon-sensitive portable and fixed alpha detectors such, as zinc sulfide or gas proportional counters, should be used.

Appropriate beta detection instrumentation should be available to measure decay products such as Protactinium-234m. If Technetium-99 is suspected, special low-energy beta particle detection equipment should be available.

Notes

If large quantities of uranium hexafluoride are present, appropriate neutron survey instruments should be available to measure the neutron radiation.

If the facility contains enriched uranium and/or Uranium-233, appropriate criticality safety alarm systems shall be in place and appropriate neutron and gamma survey instruments available.

Continuous air monitors (CAMs), sample extraction lines that go to CAMs, and continuous radiation dose monitors should be placed outside glove boxes and fume hoods.

B. Survey Techniques

Monitoring practices include, but are not limited to, the following:

- Contamination surveys of the workplace
- Release surveys
- External exposure surveys
- Airborne contamination surveys
- Routine surveillance by a Radiological Control Technician

All work areas must be monitored for contamination levels on a regularly scheduled basis. The frequency of such surveys will depend on the potential for dispensability of the radioactive material. During these routine surveys, all work enclosures, work surfaces, floors, and equipment within the workplace should be surveyed.

Notes

C. Workplace characterization

At the time a program is established, measurements of external dose should be made at all locations where it occurs to delineate the levels involved (workplace characterization). Additional measurements should be made at the same frequency as the contamination surveys to identify the buildup of uranium in HEPA filters and glove boxes.

Airborne contamination surveys should be performed for:

- Prompt detection of airborne contamination for worker protection
- Personnel dose assessment
- Monitoring of trends within the workplace
- Special studies

IV. Personnel protection requirements

Workers in uranium facilities need to be appropriately trained on the hazards. DOE has developed DOE-HDBK-1113-98*, Radiological Safety Training for Uranium Facilities*, 1998. This handbook provides DOE's guidance on expectations for training of uranium workers.

A. Personnel air sampling

The use of personnel air sampling programs should be considered in monitoring individual Radiological Workers.

B. Protective clothing

As a minimum, personnel who perform operations in controlled areas should wear

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coveralls, gloves, and shoe covers. No personal outer clothing should be permitted under coveralls. For inspections or visits, lab coats, gloves, and shoe covers may be permissible.

Protective clothing should be removed at the step-off pad, and personnel monitoring for contamination shall be performed. If this is not practical, strict control of the movement of personnel shall be maintained from the step-off pad to a location where protective clothing can be removed. Personnel wearing protective clothing shall not be allowed to mingle with individuals wearing personal street clothing. Protective clothing shall not be allowed in uncontrolled areas such as offices, lunchrooms, or control rooms.

C. Respiratory protection

Respiratory protection should be readily available. Respiratory protective equipment should be used for all bag-out operations, bag and glove changes, and any situation involving a potential or actual breach of confinement.

V. External dose control

A. Beta radiation

Beta radiation is usually the dominant external radiation hazard in work with unshielded forms of uranium. The primary concern is Protactinium-234m, though other radionuclides may be present. Particular care should be taken in operations such as melting and casting, where decay products could be separated and concentrated. Appropriate measurements should be made of the material and appropriate extremity dosimetry worn by workers handling the material.

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B. Gamma radiation

Gamma radiation is normally not the controlling factor at uranium facilities. However, significant gamma fields can exist in areas where large quantities of uranium are stored. Appropriate actions including time, distance, and shielding considerations should be taken to maintain radiation doses ALARA.

C. Neutron radiation

Neutron radiation from enriched uranium fluoride compounds should also be considered in determining potential external radiation hazards.

VI. Internal dose control

Intakes

In most uranium facilities, the primary radiological hazard is the potential for internal intakes of uranium. This hazard must be controlled by appropriate facility and equipment design, contamination control procedures, and protective clothing.

Inhalation is the primary route of concern. Uranium transported from the lungs is deposited in the bone (22%), kidney (12%), or other tissues (12%), or excreted (54%), according to International Commission on Radiological Protection (ICRP) Publication 30.

Control must be verified by a bioassay program. Urinalysis is the most common technique, but fecal analysis and *in vivo* monitoring may also be appropriate.

Notes

DOE-STD-1121-99, *Internal Dosimetry,* provides technical guidance on internal dosimetry programs, including evaluation of occupational internal doses from exposure to radon and thoron. This standard should be reviewed prior to conducting assessments of internal dosimetry programs.

VII. Special controls and considerations at uranium operations

A. Criticality alarm systems (gamma or neutron) shall be provided in each area where an accidental criticality is possible. Site requirements documents relating to criticality alarms should be reviewed prior to the assessment, if applicable. These requirements may include: ANSI/ANS 8.1, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*; ANSI/ANS 8.3 *Criticality Accident Alarm* Systems; ANSI/ANS 8.7, *Nuclear Criticality Safety in the Storage of Fissile Materials*; ANSI/ANS 8.15, *Nuclear Criticality Control of Special Actinide Elements*; and ANSI/ANS 8.19, ANS *Administrative Procedures for Nuclear Criticality*.

B. All DOE facilities that possess sufficient quantities and kinds of fissile material to constitute a potentially critical mass shall provide nuclear accident dosimetry (fixed and personal). The number of dosimeters needed and their placement will depend on the nature of the operation, structural design of the facility, and accessibility of areas to personnel. An analysis of the dosimeters and their placement should be conducted and documented.

Notes

C. Uranium metal in finely divided form is pyrophoric; therefore, any grinding or milling operations must be carefully conducted to avoid fires.

   Uranium hexafluoride is commonly found in many uranium operations. This material is a solid at room temperatures but volatilizes readily at elevated temperatures. As a gas, it is extremely hazardous, forming hydrofluoric acid when it comes in contact with water. Operations involving uranium hexafluoride must be conducted very carefully to prevent release of the gas.

D. External radiation hazards from uranium are primarily associated with decay products; therefore, operations in which the decay products can separate and concentrate must be monitored carefully. For example, crucibles used to melt depleted uranium and casks used to ship uranium hexafluoride are sometimes more radioactive after they are emptied than when they are full. The reason is that the decay products are left in the emptying process and are no longer self-shielded by the uranium.

Notes

I. Introduction

II. Radiological aspects of tritium

A. There are three primary sources of tritium. These are:

1. Environmental sources - Reactions between cosmic rays and the upper atmosphere

$$^{14}N + {}^{1}n \rightarrow {}^{3}H + {}^{12}C$$

$$^{2}H + {}^{2}H \rightarrow {}^{3}H + {}^{1}H$$

2. By-product of power reactors

- Ternary fission - A fission event resulting in fission fragments, one of which is tritium. Occurrence typically has a 0.1% yield.

B-10 (n, 2 alpha) ^{3}H

Li-7 (n, n alpha) ^{3}H

3. DOE production of tritium (Hanford, Savannah River reactors) is by the following reaction:

$$^{6}Li + {}^{1}n \rightarrow {}^{3}H + \text{alpha}$$

Notes

B. Chemical and radiological properties of tritium

1. Chemical forms

- Elemental tritium (tritium gas, HT, DT, T_2)

- Tritiated water (tritium oxide, HTO, DTO, T_2O)

- Special tritium compounds (STCs): created by intentional combination of tritium with the desired materials or by inadvertent contamination of a material that has been subjected to the presence of tritium for a period of time.

  These are classified in a number of ways, depending on their host material (metal or organic), rate of tritium release (stable or unstable), and physical form (particulate or non-particulate). They include:

  - Organically bound tritium (OBT); the main types of OBT encountered in the DOE complex are solvents, oils, and solid particulates (e.g., plastics, nylon, and organic dust forms).

  - Particulates; stable or insoluble forms are referred to as stable tritiated particulates (STPs).

Notes

2. Radiological properties

- $^{3}H \rightarrow {}^{3}He$ + beta minus and anti-neutrino
- E_{max} = 18.6 keV, E_{avg} = 5.69 keV
- Half-life = 12.32 years
- Specific activity = 9619 Ci/gram
- ALI_{water} = 3000 MBq = 8 E4 μCi (inhalation and ingestion)
- DAC_{water} = 0.8 MBq/m^3 = 2 E-5 μCi/cm^3
- $DAC_{elemental}$ = 2 E4 MBq/m^3 = 0.5 μCi/cm^3
- f_1 = 1
- Committed dose equivalent per unit intake = 1.73 E-11 Sv/Bq = 6.4 E-2 mrem/μCi
- $DAC_{elemental}/DAC_{water}$ = 25,000

In addition, DOE has issued guidance on radiological protection for special tritiated compounds in Radiological Control Technical Position, RCTP 99 - 02, *Acceptable Approach for Developing Air Concentration Values for Controlling Exposures to Tritiated Particulate Aerosols and Organically-Bound Tritium.*

DOE has also developed a technical standard, now in draft, *Radiological Control Programs for Special Tritium Compounds*, DOE-OSCH-0002.

Notes

C. Potential exposure pathways of tritium

Dose pathways and biological effects

- Inhalation
  - Elemental tritium (tritium gas) - Limiting condition is exposure to the lung
  - Approximately 0.005% of HT inhaled is converted to HTO prior to exhalation
  - Nearly 100% of inhaled HTO is incorporated into body fluids/tissues.

- Ingestion
  - Tritiated water
    - Assumed to be instantaneous
    - Biological half-life is normally ten days, but may be reduced by a factor or two-three with increased fluid intake

- Skin absorption of HTO through intact skin ≈50% of that inhaled.

For different modes of entry of STCs:

- STPs behave with the characteristics of the particle to which they are attached.

- Soluble OBT distributes throughout the body causing a whole body dose. Insoluble OBT can be taken into the body by inhalation when in particulate form. Airborne droplets of insoluble components of oils may be treated as stable particulates.

Notes

D. General sources of tritium releases

1. Gaseous releases - ventilation exhaust systems

2. Liquid wastes

   - Aqueous

   - Organic (e.g., oils)

3. Solid wastes

   - Contaminated wastes

   - Treatment residues

E. Exposure controls for tritium

The personnel protection requirements for tritium include:

- Airborne contamination controls

- Surface contamination controls

1. Airborne controls

   - Differential room pressure zones

   - Dilution ventilation

   - Room-air detritiation systems

   - Local exhaust ventilation

Notes

2. Contamination controls

   - Good housekeeping
   - Good work practices

3. Personnel protective equipment

   - Air supplied respirators
   - Protective clothing

F. Metabolism of tritium

The tritium beta lacks sufficient energy to penetrate the dead cell layer in skin. Therefore, it is of little consequence as an external hazard. The beta particles can produce Bremsstrahlung radiation when they interact with matter, although the tritium Bremsstrahlung is extremely low energy. It is remotely possible that the Bremsstrahlung exposure could become significant around materials with very high specific activities and little or no shielding.

Tritium can deliver a radiation dose if it gets inside the body. Modes of entry include:

- Inhalation
- Ingestion
- Absorption

1. Inhalation

   Tritium gas (HT) is only slightly incorporated into the body when inhaled. Approximately 0.005% of HT inhaled is converted to tritiated water prior to being exhaled. Depending upon the rate at which HT converts to HTO *in vivo,* it is possible that some dissolved HT may be excreted in urine.

Notes

Tritiated water (HTO) is much more radiologically hazardous than tritium gas. Inhaled HTO enters the body through the lung fluids with 100% efficiency, and mixes rapidly with body water. Nearly 100% of tritiated water (HTO) inhaled is incorporated into body fluids and tissues.

2. Ingestion

   Ingested HTO is assumed to be completely and instantaneously absorbed from the gastrointestinal tract and mixes rapidly with the body fluids so that following ingestion, the concentration in sweat, sputum, urine, blood, perspiration and expired water vapor is the same.

3. Absorption

   There is negligible skin absorption for tritium gas. Some HT can be absorbed through the skin from contact with surface contamination. This uptake is probably in the form of HTO, resulting from the oxidation of HT. Some tritium may be retained in the skin in the form of organics, presumably resulting from exchange reactions with HT on or in the skin.

   HTO can be readily absorbed through the skin. It will be uniformly distributed in all biological fluids within one to two hours.

   Most exposures are to HTO, which rapidly enters the body water via absorption through the lungs and/or skin. A small amount of HT can dissolve in lung fluids, convert to HTO, and enter the body fluids. Exposures to HTO are approximately 10,000 to 25,000 times more hazardous than exposure to HT. HTO has an effective half-life in the body in the range of 4 to 18 days, with a mean effective half-life of about 9 or 10 days.

Notes

Most tritium leaves the body either in urine or through evaporation from the lungs and skin. The dose commitment from an uptake of one curie of HTO is approximately 63 rem.

For the above 3 discussed modes of entry: STPs and insoluble components of tritiated oils behave with the characteristics of the particle to which they are attached.

For dose calculations for STPs, ICRP Publication 66 uses absorption types; slow, medium, and fast (S, M, F). These are used in place of the lung retention classes (day, week, and year; D, W, Y) used in ICRP Publication 30. Depending on the absorption type of the compound, the dose per intake will be different than HTO.

For example: The air concentration value (which could be used in assessing dose per intake) for Type S STP is 10 times more restrictive than HTO, while the air concentration value for Type F STP is 5 times less restrictive than HTO.

Soluble OBTs act somewhat similar to HTO, however a larger percentage of nuclear transformations occur in the stomach. The dose per intake is approximately twice that of HTO.

Skin absorption is also a valid intake pathway for tritiated oil components and solvent OBT.

G. Methods of tritium containment

1. Primary - Process equipment and piping

2. Secondary

   - Glove boxes

   - Temporary vented enclosures

Notes

3. Tertiary - Room and associated ventilation systems

    - Effluent recovery systems
    - Emergency containment systems

H. Airborne tritium controls

1. Differential room pressure zones - The air ventilation system plays a key role in controlling the spread of contamination. In addition to providing the necessary humidity and temperature control for a building, differential pressure zones should be established within a building to ensure that the air flows from areas with lower hazardous contamination potential to areas with more hazardous contamination potential.

2. Dilution ventilation - Dilution ventilation is the once-through flow technique of exchanging outside air for inside air for comfort and basic contamination control.

3. Room-air detritiation systems - Such a system uses tritium monitors located in the room exhaust to activate (close) fast acting dampers. The dampers then route the exhaust through a special oxidation/drying system and return the air to the room.

3. Local exhaust ventilation - The primary advantage of local exhaust ventilation techniques is the removal of airborne tritium, regardless of its evolution rate or chemical or physical form. In addition, these techniques use relatively low flow rates compared to normal ventilation requirements.

Notes

I. Measurement techniques for tritium

1. Air monitoring - Fixed and portable ionization chambers most widely used.

2. Differential monitoring - Separate monitoring of HT and HTO components through the use of bubblers in conjunction with desiccants or catalysts.

3. Discrete sampling - Samples collected with a bubbler or "cold finger" type sampler, then later analyzed by liquid scintillation counting techniques.

4. Process monitoring

   - Stack, room, hood, glove box

   - Mass spectroscopy, gas chromatography, calorimetry

5. Surface monitoring

   - Difficult to measure directly due to low-energy emission

   - May have some success with thin window GM (pancake style probe), thin window sodium iodine, or gas flow proportional counters

   - Smears taken for loose contamination, and measured by dissolution and analysis by liquid scintillation counting techniques

6. Liquid Monitoring - Liquid scintillation counting techniques

Notes

J. Bioassay program for tritium workers

An adequate bioassay program for tritium workers would test for chronic and acute exposure.

1. Chronic exposure - Periodic urinanalysis for tritium (daily to biweekly identified in Tritium Good Practices Manual)

2. Acute exposure

   - Wait one to two hours.
   - Void bladder.
   - Collect sample as soon as possible thereafter.
   - Continue to collect daily to determine individual half-life.

Dose from exposure to STCs may need to be assessed based on air monitoring results, see RCTP 99-02.

DOE-STD-1121-99, *Internal Dosimetry*, 1999, provides guidance on internal dosimetry programs including monitoring and assessing dose from tritium.

K. Tritium effluent recovery systems

1. Purpose - Reduce tritium available for release

2. Method - Tritium gas converted to HTO and ultimately a stable waste form

Notes

L. Inventory control and accountability for tritium

1. Nuclear materials, including tritium, need to be controlled and have material accountability.

2. Appendix D to the Tritium Good Practices Manual discusses inventory control and defines it to consist of:

   - Measurements
   - Measurement controls
   - Determination of holdup in systems
   - Development of predictors
   - Establishment of accounting practices